

Harmonized Dose Expression for the Zonal Evaluation on Plant Protection Products in High Growing Crops

Working group: Globular trees (Citrus)

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Instituto Valenciano de Investigaciones Agrarias (IVIA)

**EPPO Panel on Efficacy Evaluation of Fungicidas and Insecticides
Barcelona, 28- 11- 2017**

EPPO workshop, WG of Globular trees, Vienna, Oct. 2016



□ Key conclusions

- Starting point → Kick-off for a WG on dose expression (& adjustment?) in globular tree orchards (GTOs) – we are at an initial stage!
- Proposal for **present & short-term** approach → Continue using product **concentration**, combined with rationalized (& harmonized) water rates.
- Proposal for **mid-term** → Since **validation** is missing for proposed models in GTOs (**LWA, TRV, GTV**), proposal to dedicate 2 years to generate new trial data with **harmonized study protocols**. Independent analyses of anonymized trial data by crop experts. Final decision based on robustness and practicality

Dose expression for citrus WG Meeting , Valencia, April 2017



- ❑ ECPA working group (JM Cantus, R Burkhardt, X Van Waetermeulen, M Teichmann, P Schlotter)
- ❑ AEPLA (A Soler, M Torné, C Blanco, C Palomar, J Navacerrada)
- ❑ MAPAMA (I Bravo)
- ❑ INIA (E Gutierrez)
- ❑ IVIA (A Tena, A, Fonte, C Garcerá, P Chueca)

□ Summary and conclusions

- ✦ Industry proposes efficacy trials product rates/tLWA
 - Max 3000 L/ha inner pest
 - Max 1500 L/ha outer pest and for fungicides
- ✦ IVIA proposes TV or TRV
- ✦ No agreement was found → Next steps
 - A → Set up development trials comparing LWA vs TRV treatments → For 2018
 - B → Use concentration linked with Citrusvol tool → Explore possibility

Development of scientific data about what the proposed models (LWA, TRV, GTV) is adequate for Citrus

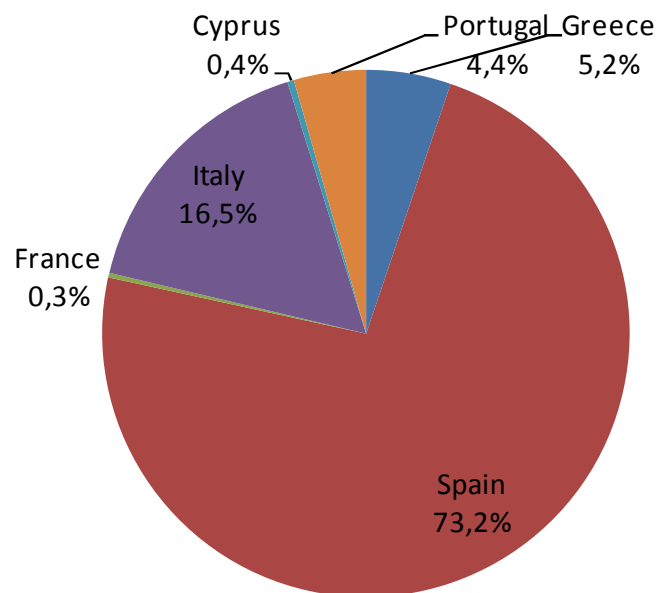
Citrus

Europe

Acreages 1000 ha

Table 16	Oranges	Mandarins	Satsumas	Clementines	Lemons	Grapefruit	Citrus	Citrus
	(CISD)	(CIDNO)	(CIDUN)	(CIDTG, CIDDE)	(CIDLI, CIDAF)	(CIDPA, CIDGR)	total	in %
	X 1000 ha	X 1000 ha	X 1000 ha	X 1000 ha	X 1000 ha	X 1000 ha	X 1000 ha	
Mediterranean zone	300,6	139,8	68,4	433,7	79,4	12,4	1034,3	100,0
Greece	38,8	4,3	0,1	4,6	6,2	0,2	54,2	5,2
Spain	137,8	121,5	46,3	398,5	42,1	11,3	757,5	73,2
Southern France	0,4	0	0	1,7	0,2	0,3	2,6	0,3
Italy	103,4	9,6	0	27,9	29,2	0,3	170,4	16,5
Cyprus	1,6	0,7	0	1,1	0,7	0,5	4,6	0,4
Portugal	18,7	3,6	22	0	1	0	45,3	4,4

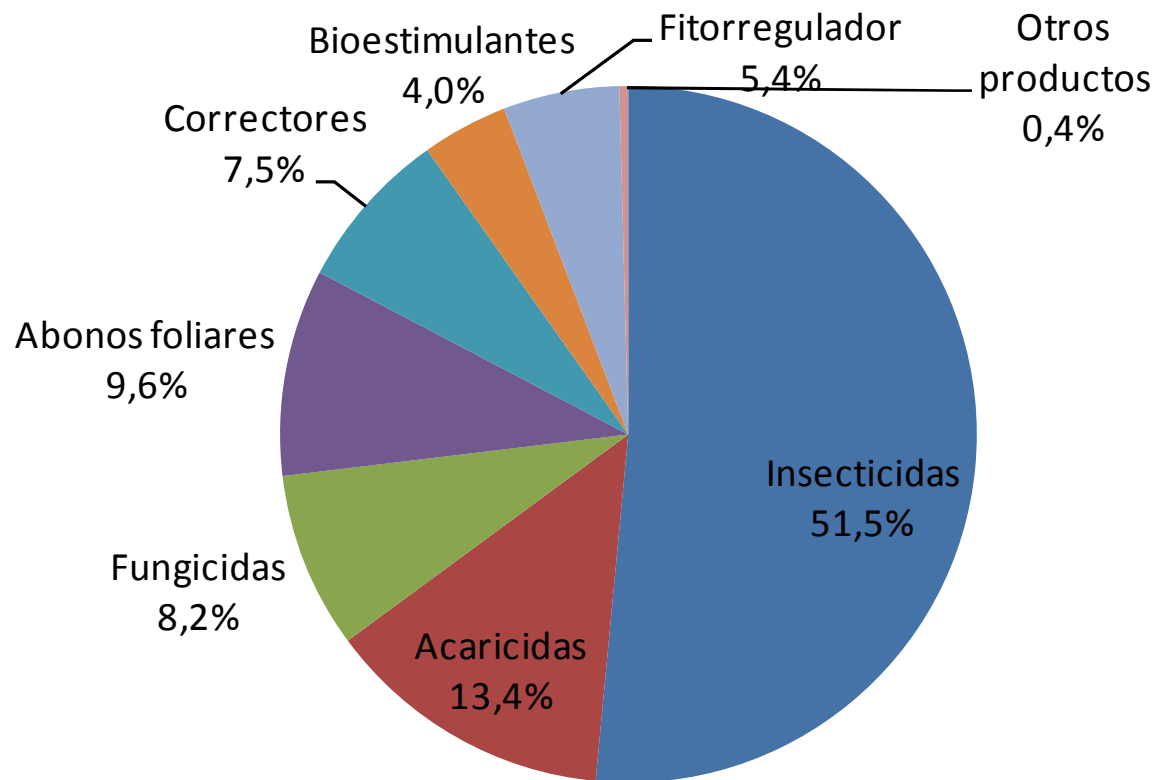
Fuente: Euroscope



□ Spain

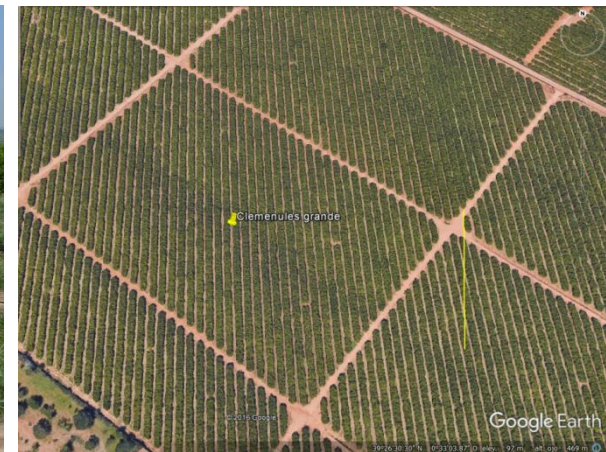
- 6th worldwide producer → 1st exporter for fresh consumption
- 311500 ha → 5.500.000 tn
 - 53% Oranges
 - 34% Mandarins
 - 12% Lemons
- C. Valenciana → 168.000 ha (55% nacional)
- Andalucía → 83.000 ha (28%)
- Murcia → 37.700 ha (12%)

▣ Pesticide market in citrus



Fuente: ECPA Panel citrus ; Survey 2016

Citrus orchards



Citrus orchards



Citrus orchards – Superintensive (Experimentation)



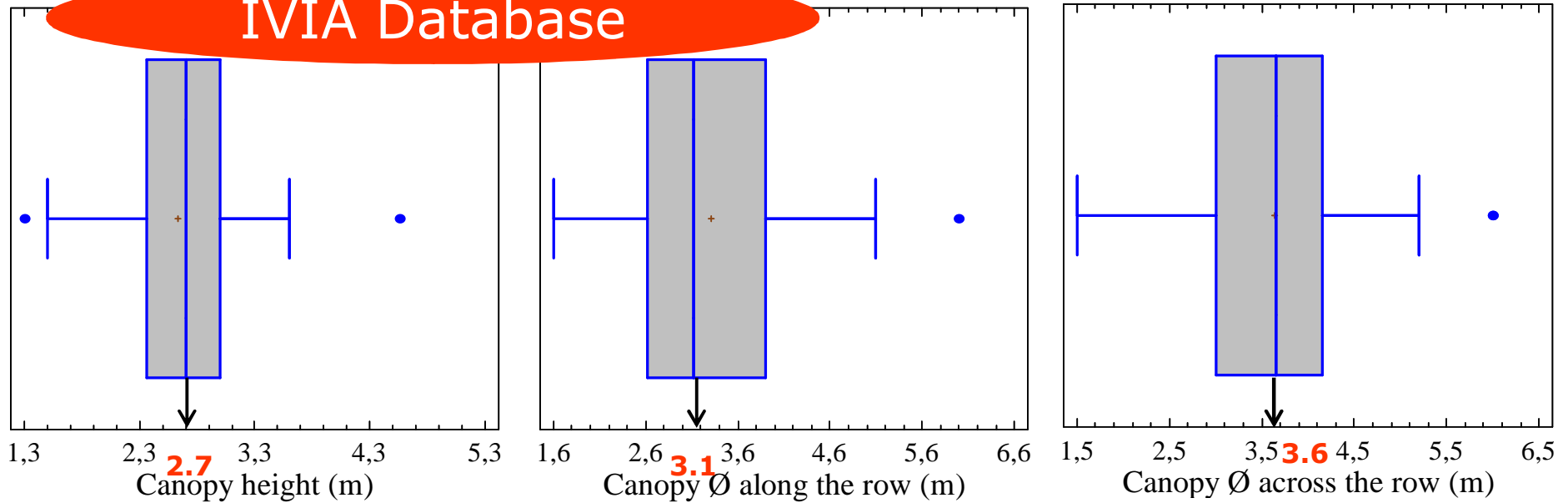
Citrus orchards -characteristics

□ Database → commercial orchards characteristics

- ↘ Height of trees
- ↘ Diameter across the row
- ↘ Diameter along the row
- ↘ Foliar density

Citrus orchards -characteristics

IVIA Database



ECPA Database



SOURCE; 144 TRIALS



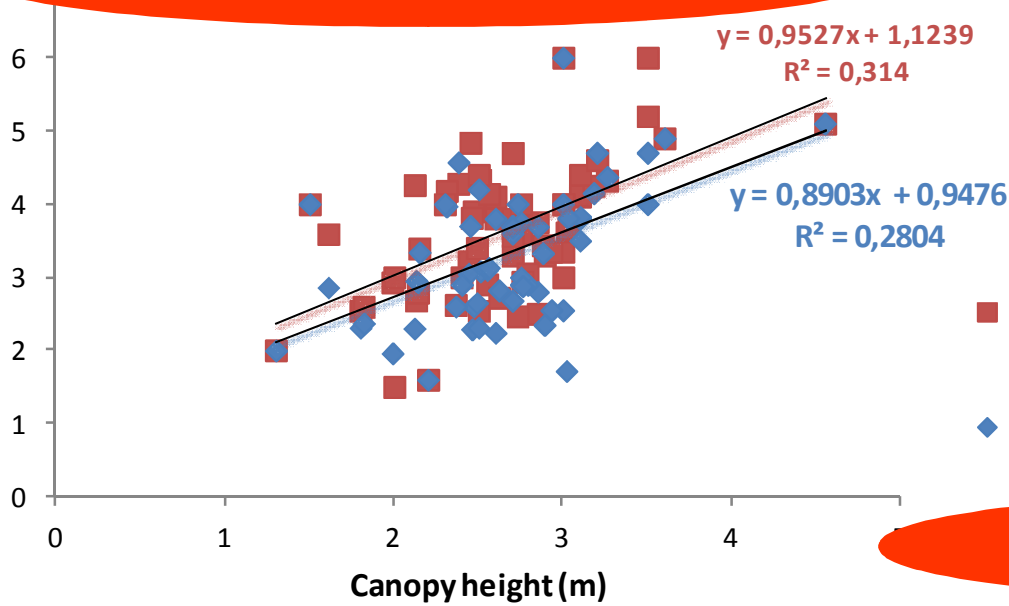
SOURCE; 113 TRIALS



ivia

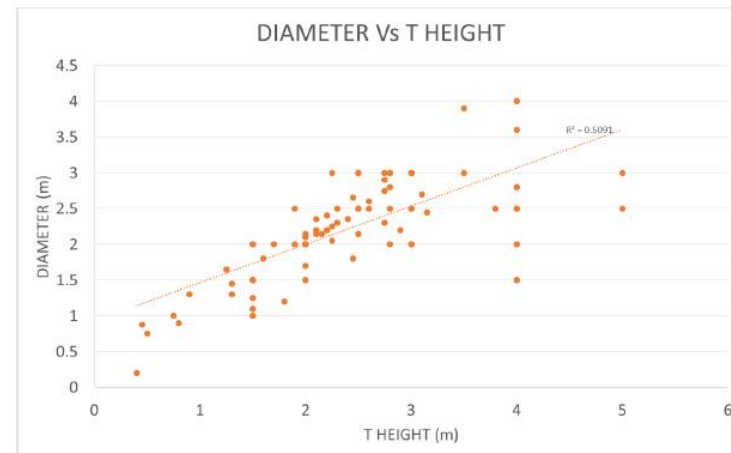
Citrus orchards - characteristics

IVIA Database



ECPA Database

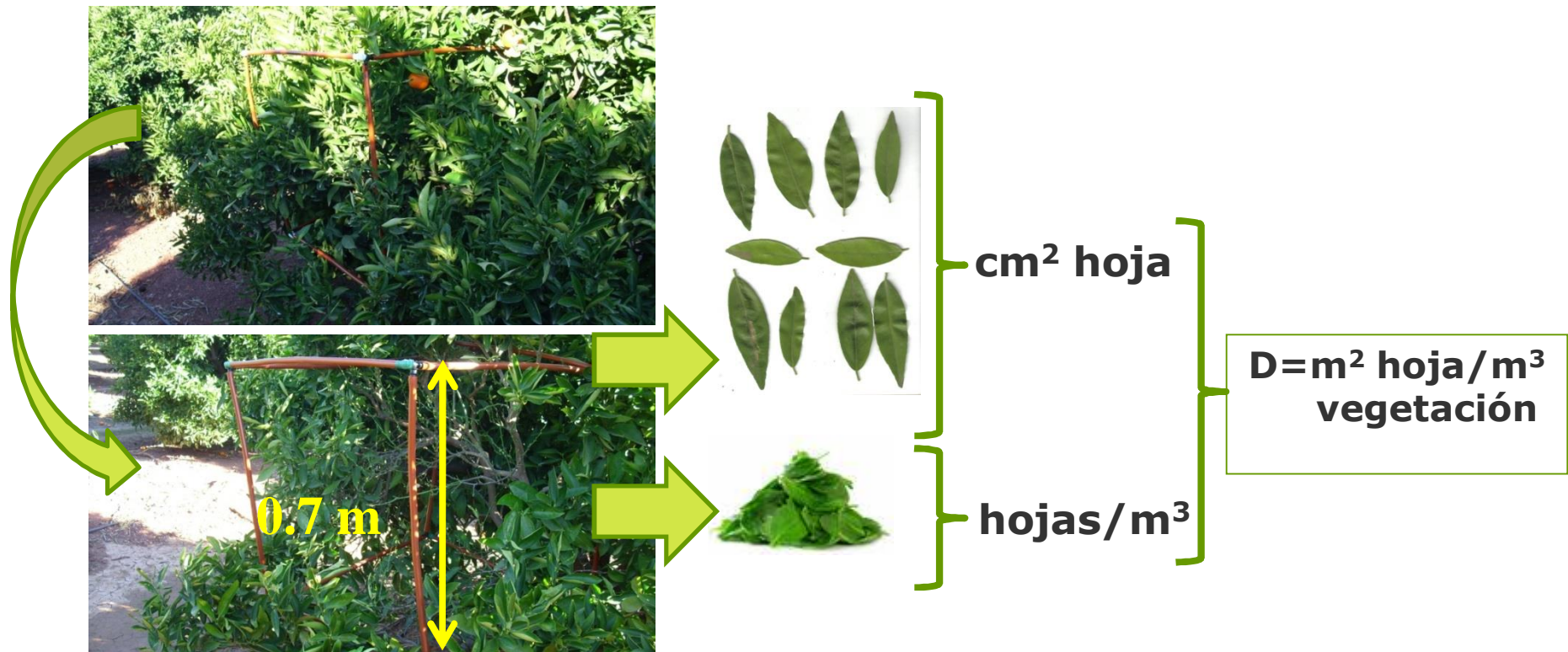
DIAMETER Vs t-HEIGHT



SOURCE: 113 TRIALS

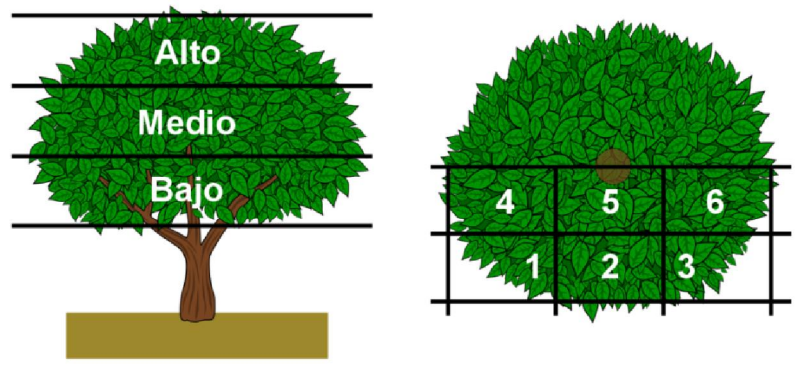
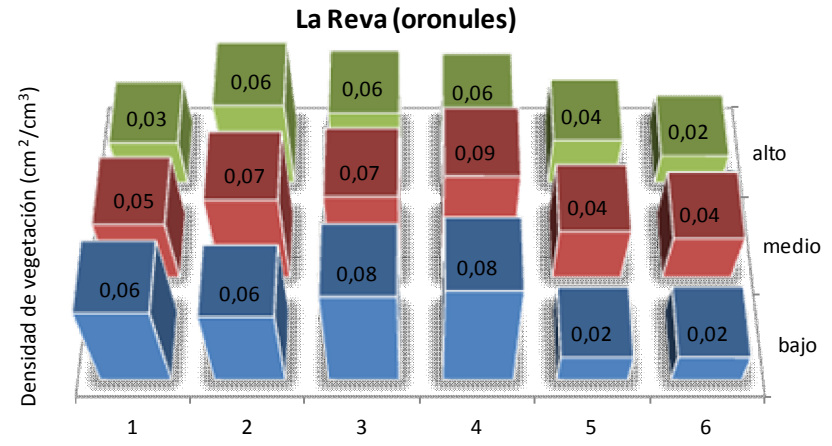
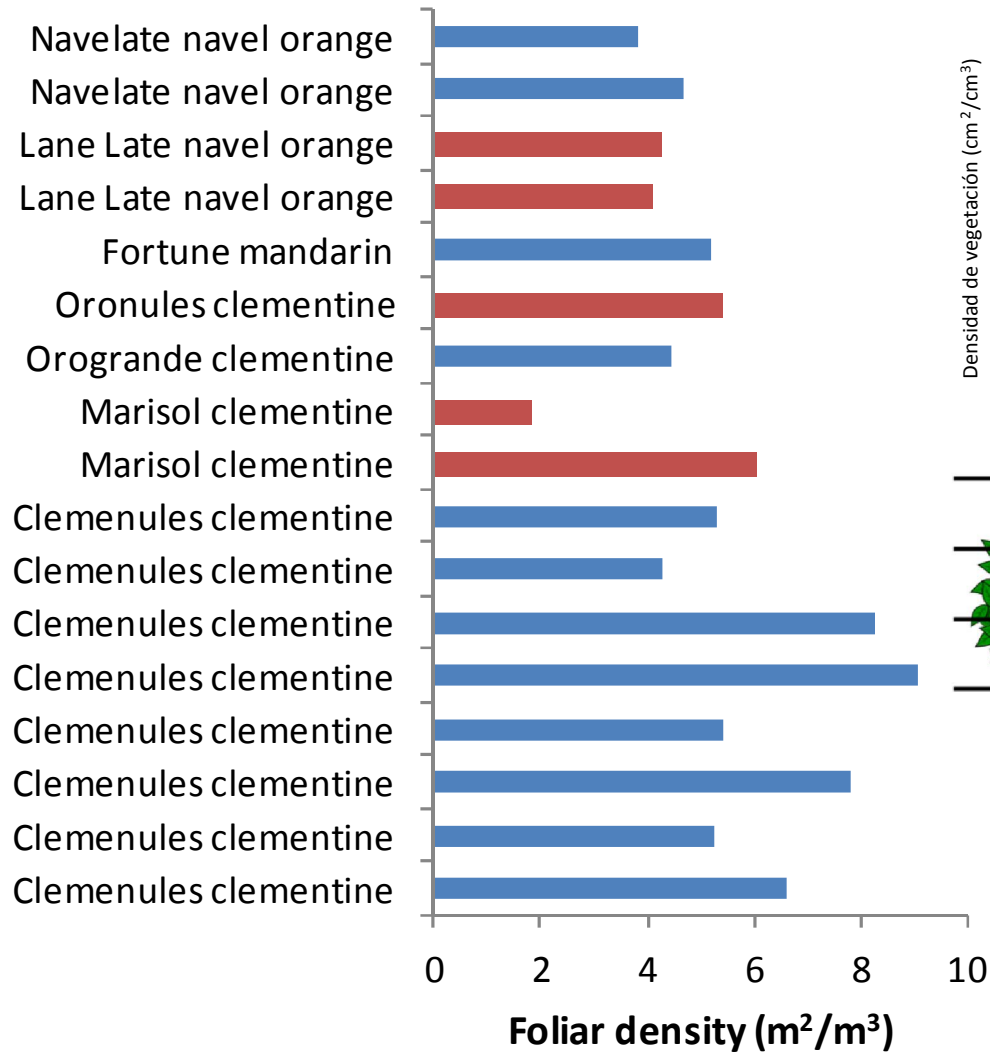


Foliar density(m^2 hoja/ m^3 vegetación)



Citrus orchards - characteristics

IVIA Database



Spray application techniques in citrus*

□ Foliar treatments



- 1 operator
- **12-30 bar** → **7-12 bar**
- **3-6 km/h** → **1.5-3 km/h**
- 10-25 min/spray water
- 35-90 min/ha
- 1000-2500 l/ha (1500-4000 l/ha)



- 2 operators
- 35-50 bar
- 10-15 min/spray water
- 120-240min/ha
- 1000-4800 l/ha



* Data obtained from surveys in CV in 2005

Efficiency of spray applications with airblast sprayers in citrus

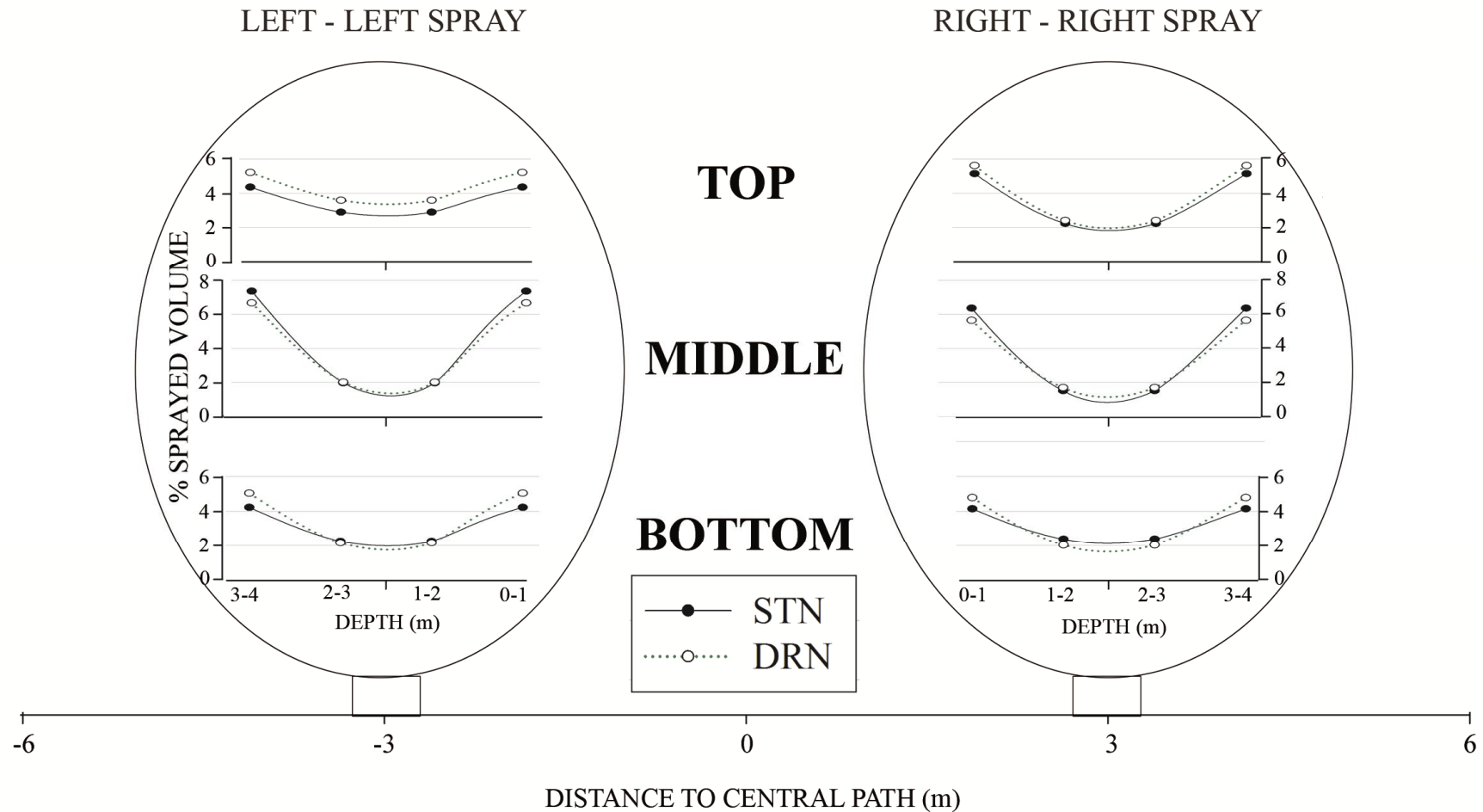


Efficiency of spray applications with airblast sprayers in citrus

Mass balance	% sprayed volume
Target canopies	46 %
Canopies of adjacent rows	4 %
Direct losses to the ground	22 %
Potential sedimenting drift	8 %
Potential airborne drift	23 %
TOTAL	103 %

Fuente: Garcerá C., Moltó E., Chueca P. 2017. Spray pesticide applications in Mediterranean citrus orchards: Canopy deposition and off-target losses. Science of the Total Environment 599-600:1344-1362.

Distribution of spray volume in the canopy



Fuente: Garcerá C., Moltó E., Chueca P. 2017. Spray pesticide applications in Mediterranean citrus orchards: Canopy deposition and off-target losses. Science of the Total Environment 599-600:1344-1362.

Definition of parameters for dosage

- ❑ **DOSE:** amount of active material distributed per unit area.
- ❑ **CONCENTRATION:** amount of product added to a unit of water volume.
- ❑ **SPRAY VOLUME:** amount of water+product distributed per unit area in the field.

$$\mathbf{DOSE = SPRAY VOLUME \times CONCENTRATION}$$

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Spain and other
Southern countries
(g/hl = g/100l, %)

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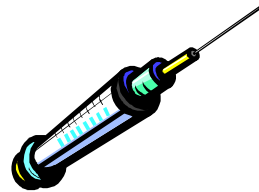
(g/hl = g/100l, %)

Spain and other
Southern countries

Limitation: L/ha

Definition of parameters for dosage

- ❑ Pharmaceuticals: dose rate adapted to the body weight



**15 kg
child**

**55 kg
lady - teacher**

**100 kg
worker**



Logical - Accepted by everybody

Dose expression

□ Treated Leaf Wall Area (tLWA)

$$\text{tLWA(m}^2\text{/ha)} = \frac{\text{Spray band height(m)}}{\text{Spacing between rows(m)}} \times 10000$$

$$\text{Spray volume(l/ha)} = 2 \times \text{LWA (m}^2\text{/ha)} \times n \text{ (l/m}^2\text{)}$$



Dose expression

□ Treated Tree Row Volume (tTRV)

Spray Height (m) x Wide (m) x 10000

$$\text{tTRV(m}^3\text{/ha)} = \frac{\text{Spray Height (m) x Wide (m) x 10000}{\text{Spacing between rows(m(m))}}$$

$$\text{Spray volume (l/ha)} = \text{TRV (m}^3\text{/ha)} \times n \text{ (l/m}^3\text{)}$$



Dose expression

□ Canopy volume

↘ Cítricos → elipsoid volume

$4 \times \text{PI}$

$$\text{CV}(\text{m}^3/\text{ha}) = \frac{4 \times \text{PI}}{3 \times \text{Spacing between row} \times \text{Spacing between trees}} \times abc (\text{m}^3) \times 10000$$

$$\text{Volumen (l/ha)} = \text{CV (m}^3/\text{ha)} \times n (\text{l/m}^3)$$



CASE OF STUDY

□ Citrus orchard characteristics:

Report	Crop	Spacing (m x m)	Canopy height (m)	Diam-cross (m)	Diam-length (m)	Shape tree *(m ³ veg/ha)	TRV (m ³ /ha)	LWA (m ² /ha)
1	Washington orange	5x4	1.5	4	4	6300	12000	6000
2	Washington orange	4x2	1.3	2	2	3400	6500	6500

*The tree shape was consider a ellipsoid

□ Treatment characteristics:

Report	Treatment	Product	[] (g/hl)	Spray vol (L/ha)	Dose (kg/ha)	Dose (kg/1000 LWA ha)	Dose (kg/1000 TRV ha)	Dose (kg/10000 m ³ veg ha)
1	1	1	20	1200	2400	4000	2000	3800
1	2	1	30	1200	3600	6000	3000	5700
1	3	1	60	1200	7200	12000	6000	11500
2	4	1	20	1300	2600	4000	4000	7600
2	5	1	30	1300	3900	6000	6000	11500
2	6	1	60	1300	7800	12000	12000	22900

CASE OF STUDY

□ Citrus orchard characteristics:

Orchard	Crop	Spacing (m x m)	Canopy height (m)	Diam-cross (m)	Diam-length (m)	TRV (m ³ /ha)	LWA (m ² /ha)	Shape tree *(m ³ veg/ha)
1	Washington orange	5x4	1.5	4	4	12000	6000	6300
2	Washington orange	4x2	1.3	2	2	6500	6500	3400

*The tree shape was consider a ellipsoid

□ Treatment characteristics:

Orchard	Treatment	Prod.	[] (g/hl)	Spray vol. (L/ha)	Dose (kg/ha)	Dose (kg/10000 LWA ha)	Dose (kg/10000 TRV ha)	Dose (kg/10000 m ³ veg ha)
1	1	1	20	1200	2400	4000	2000	3800
1	2	1	30	1200	3600	6000	3000	5700
1	3	1	60	1200	7200	12000	6000	11500
2	4	1	20	1300	2600	4000	4000	7600
2	5	1	30	1300	3900	6000	6000	11500
2	6	1	60	1300	7800	12000	12000	22900

Spray volume calculator for citrus

CITRUSVOL → gipcitricos.ivia.es



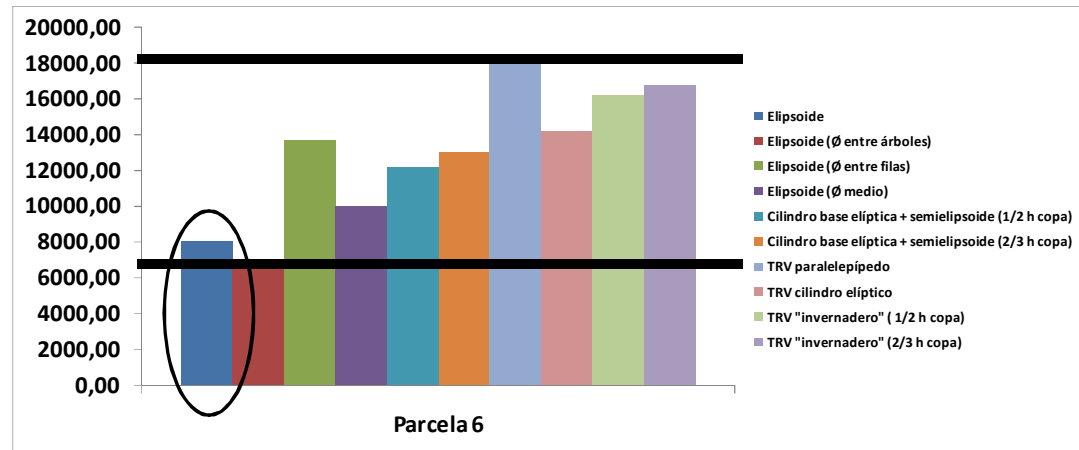
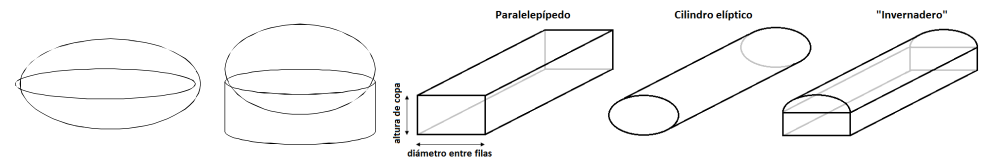
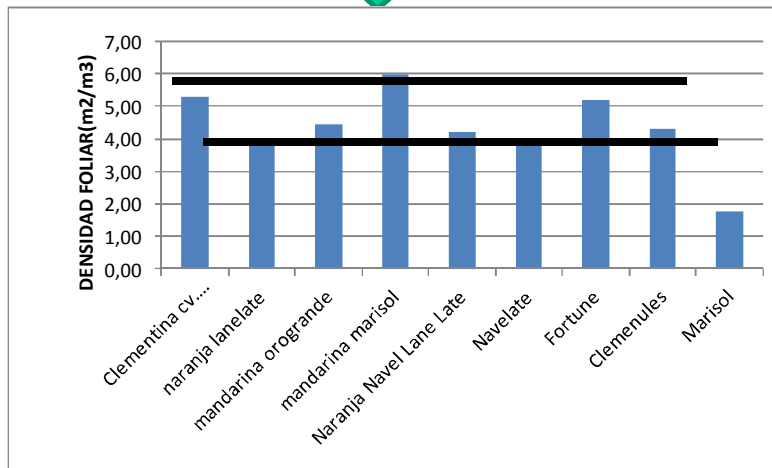
The screenshot shows the CITRUSVOL web application interface. At the top, there is a navigation menu with categories like 'PLAGAS Y ENFERMEDADES', 'PLAGAS SECUNDARIAS', 'GESTIÓN DE PLAGAS', 'ENEMIGOS NATURALES', 'EFECTOS SECUNDARIOS', 'TRATAMIENTOS FITOSANITARIOS', and 'PLAGAS EXÓTICAS'. The main heading is 'RECOMENDACIÓN DE VOLUMEN' with a sub-link 'CALCULADORAS Más recomendaciones'. Below this, a text block explains that the calculator recommends the application volume (l/ha) for an adult citrus plantation based on tree size, planting layout, leaf density, pruning level, pest/disease, and product. A box displays the volume range: 'Volumen mínimo: 2165 l/ha' and 'Volumen máximo: 2598 l/ha', with a note to check the product's technical sheet for authorization. The calculator form includes input fields for 'ALTURA DEL ÁRBOL (EN METROS)' (3), 'ANCHO DEL ÁRBOL (EN METROS)' (3.5), 'ANCHO DE LA CALLE (EN METROS)' (6), and 'DISTANCIA ENTRE ARBOLES (EN METROS)' (4). It also features dropdown menus for 'DENSIDAD FOLIAR' (Media (Clementinas, Navel, Clemenules, Nado)), 'PODA' (Normal), 'PLAGA/ENFERMEDAD' (Diaspídeos), and 'PRODUCTOS' (Clorpirifos). An 'ENVIAR' button is located at the bottom right of the form.

Published in: Garcerá C., Fonte, A., Moltó E., Chueca P. 2017. Sustainable Use of Pesticides Applications in Citrus: A Support Tool for Volume Rate Adjustment. International Journal of Environmental Research and Public Health 2017, 14, 715.

Spray volume

$$\text{SPRAY VOLUME} = \text{Foliar area (cm}^2\text{/ha)} \times \text{Min. deposit } (\mu\text{l/cm}^2 \text{ leaf)}$$

$$\text{Foliar density (cm}^2\text{/m}^3 \text{ veg)} \times \text{Veg.vol (m}^3 \text{ veg/ha)}$$



Spray volume

$$\text{SPRAY VOLUME}_t = \text{Foliar area (cm}^2\text{ leaf/ha)} \times \text{Min. deposit (}\mu\text{l/cm}^2\text{ leaf)}$$

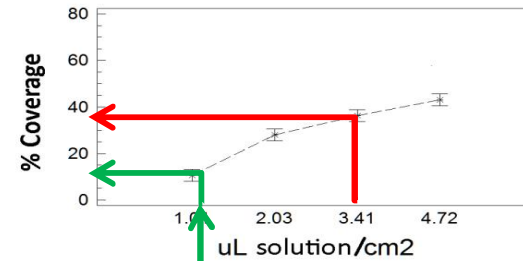
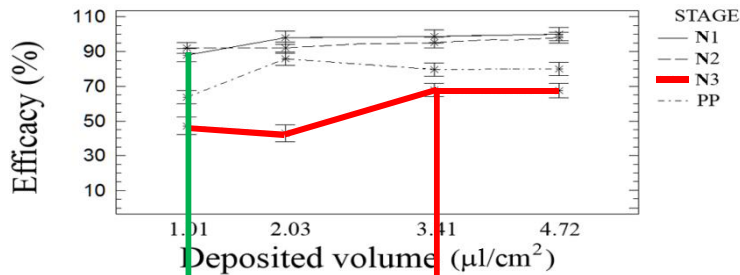
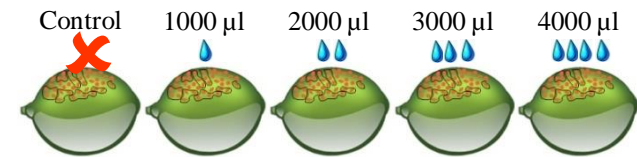
$$\text{SV}_r = \text{SV}_t / \text{Efficiency}$$



Deposition



Efficacy



Minimum deposit of chlorpyrifos mixture for young stages and adult females

Factors:
-Product
-Pest

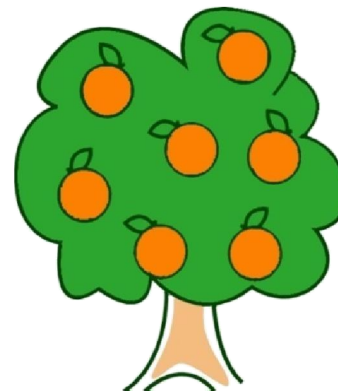
Determination L/m³ vegetación

Minimum deposit ($\mu\text{l}/\text{cm}^2$)

Leaf Area Density (m^2/m^3) + Volumen vegetación m^3/ha (Canopy volume + Trees/ha)



spray application volume (L/m³ vegetación - ha)



Validation CITRUSVOL

Conventional Volume vs Adjusted Volume

2016

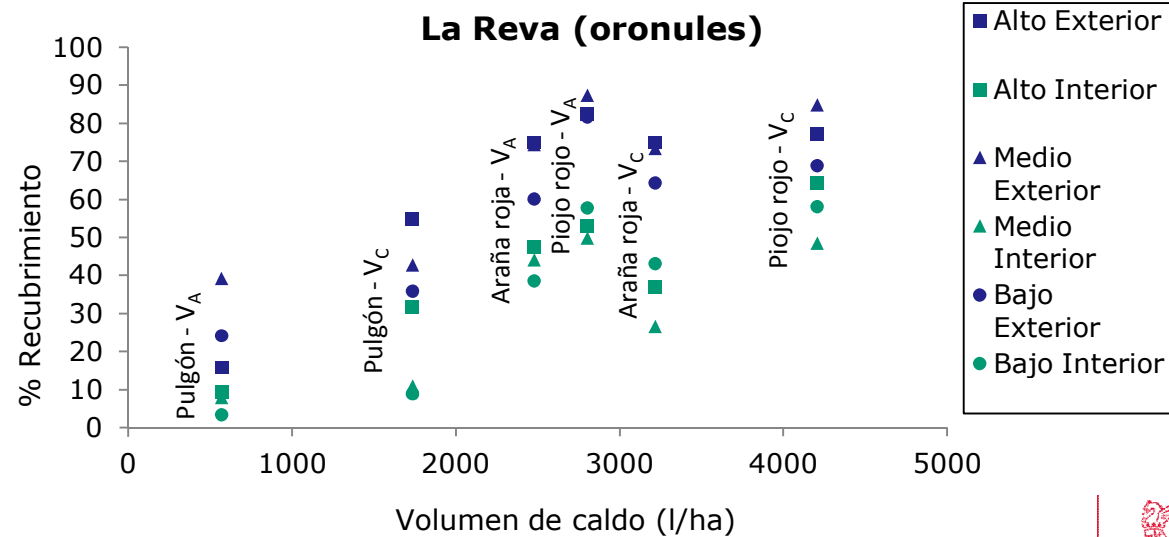
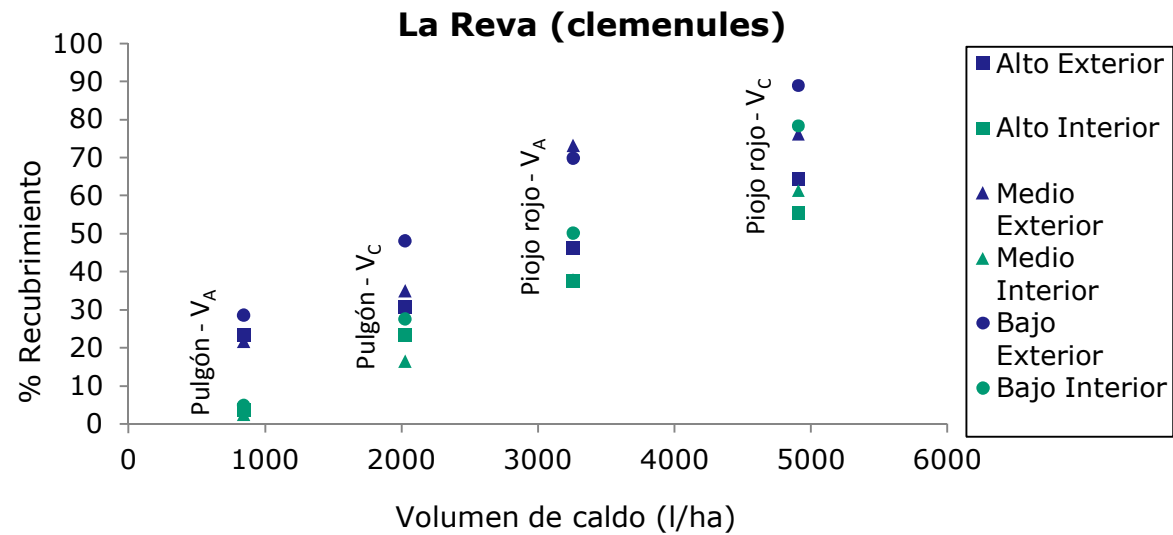
Parcela	Fecha de tratamiento	Plaga	Volumen convencional (l/ha)	Volumen ajustado (l/ha)	% Reducción Vc-Va	Volumen convencional ajuste nube (l/ha)	% Reducción Vc-Vc _{ajuste nube}
Reva clemenules	20/04/2016	Pulgón	2019.73	840.00	58.41	1806.93	10.54
	27/05/2016	Piojo rojo (1ª gen.)	4905.07	3254.93	33.64	4388.27	10.54
	27/07/2016	Piojo rojo (2ª gen.) y araña roja	4905.07	3254.93	33.64	4388.27	10.54
	11/10/2016	Araña roja	4905.07	3254.93	33.64	4388.27	10.54
Reva oronules	26/04/2016	Pulgón	1731.20	566.40	67.28	1339.73	22.61
	26/05/2016	Piojo rojo (1ª gen.)	4204.34	2800.30	33.39	3253.64	22.61
	22/06/2016	Araña roja 1	3215.09	2476.19	22.98	2488.08	22.61
	09/08/2016	Piojo rojo (2ª gen.) y araña roja	4204.34	2800.30	33.39	3253.64	22.61
	09/09/2016	Araña roja 2	3215.09	2476.19	22.98	2488.08	22.61
Gausa	18/04/2016	Pulgón	2386.22	427.06	82.10	1470.12	38.39
	09/06/2016	Piojo rojo (1ª gen.)	3263.69	2294.27	29.70	2294.27	29.70
Almaterra I	21/04/2016	Pulgón	2558.18	1188.22	53.55	2402.40	6.09
	31/05/2016	Piojo rojo (1ª gen.)	7311.44	3010.59	58.82	6881.35	5.88
Almaterra II	21/04/2016	Pulgón	1569.67	450.80	71.28	1467.67	6.50
	31/05/2016	Piojo rojo (1ª gen.)	6702.15	1737.17	74.08	5913.66	11.76
Mas de Moya L	13/06/2016	Piojo rojo (1ª gen.)	3200.90	2534.65	20.81	2838.80	11.31
	12/08/2016	Piojo rojo (2ª gen.)	3318.40	2627.69	20.81	2943.02	11.31
Mas de Moya C	14/06/2016	Piojo rojo (1ª gen.)	3467.64	3064.91	11.61	3467.64	0.00
	11/08/2016	Piojo rojo (2ª gen.)	3594.93	3177.42	11.61	3594.93	0.00

Conventional Volume vs Adjusted Volume

2017

Parcela	Fecha de tratamiento	Plaga	Volumen convencional (l/ha)	Volumen ajustado (l/ha)	% Reducción Vc-Va	Volumen convencion al ajuste nube (l/ha)	% Reducción Vc-Vc _{ajuste} nube
Reva clemenules	07/06/2017	Piojo rojo 1 y araña roja	4899.00	3487.20	28.82	4360.02	11.00
	24/07/2017	Araña roja	4899.00	3152.91	35.64	4360.02	11.00
	08/09/2017	Piojo rojo 2 y araña roja	4899.00	3152.91	35.64	4360.02	11.00
Reva oronules	22/08/2017	Piojo rojo y araña roja	4199.14	2069.85	50.71	3184.33	24.17
Gausa	23/06/2017	Piojo rojo y araña roja	3395.45	1461.50	56.96	2531.42	25.45
	03/08/2017	Araña roja	2949.65	1502.40	49.07	2170.18	26.43
Almaterra I	26/06/2017	Piojo rojo y araña roja	4262.11	2997.53	29.67	3316.46	22.19
	18/09/2017	Araña roja	4262.11	2997.53	29.67	3316.46	22.19
Almaterra II	27/06/2017	Piojo rojo y araña roja	3673.87	1811.38	50.70	2807.02	23.59
	19/09/2017	Araña roja	3673.87	1811.38	50.70	2807.02	23.59
Mas de Moya L	10/07/2017	Araña roja 1	4274.54	2566.59	39.96	3786.03	11.43
	01/08/2017	Araña roja 2	3466.67	2510.67	27.58	3262.67	5.88
	23/08/2017	Araña roja 3	3909.51	2492.97	36.23	3909.51	0.00
	14/09/2017	Araña roja 4	4589.87	2513.83	45.23	4319.77	5.88
Mas de Moya C	30/06/2017	Piojo rojo y araña roja	3932.24	3290.28	16.33	3932.24	0.00
	04/08/2017	Araña roja	3701.36	3245.91	12.30	3701.36	0.00

Coverage of spray applications with airblast sprayers in citrus



Coverage of spray applications with airblast sprayers in citrus

$$\text{Coverage (\%)} = 40.0445 + 0.0184312 \text{ Spray Vol} - 0.000000165111 \text{ Spray Vol}^2 - 0.000166146 \text{ Foliar \u00c1rea} - 7.37912 \text{ Advance Speed}$$

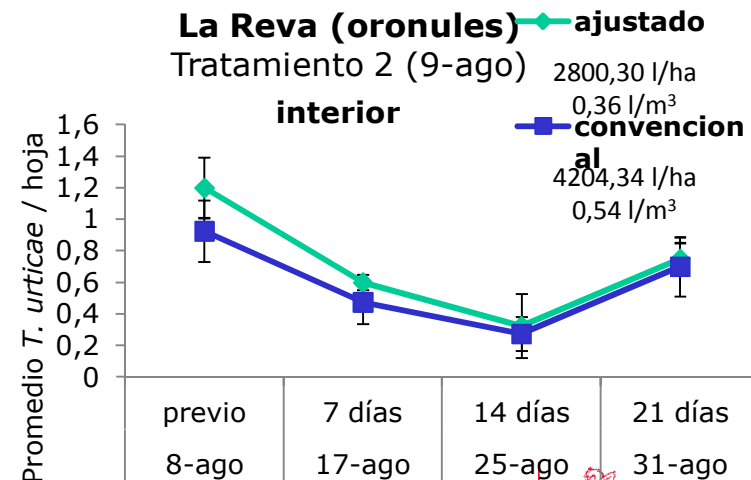
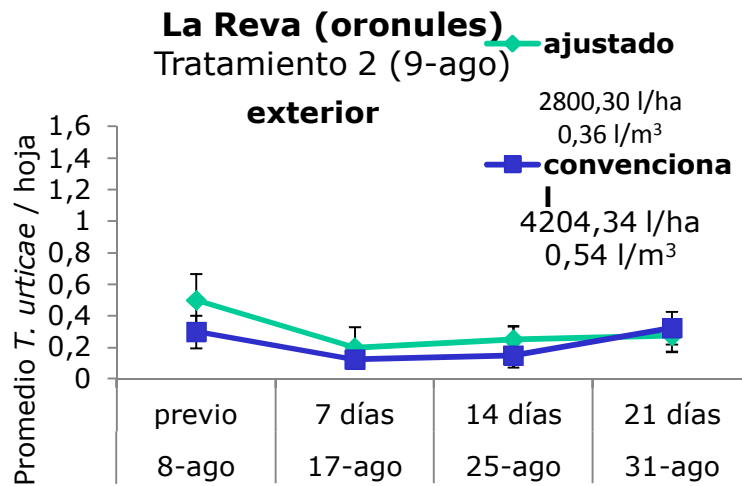
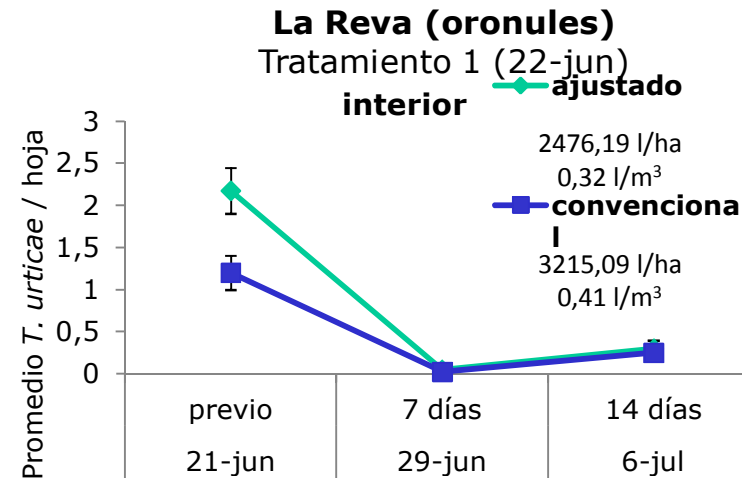
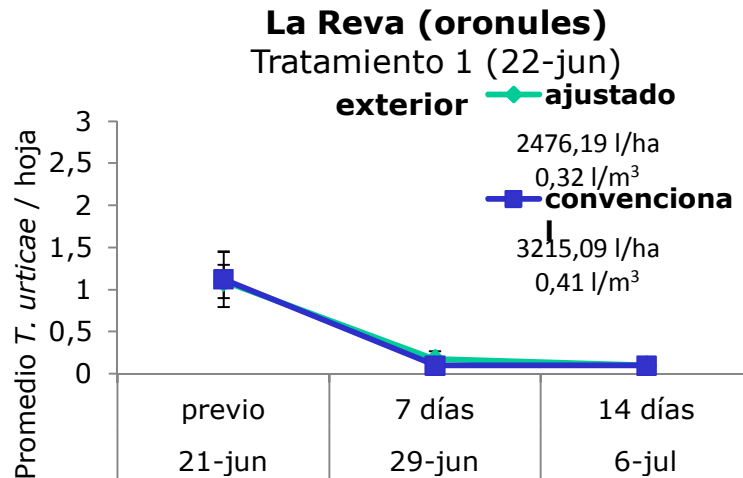
R²=90.54 %

Parameter	P-value
Constant	0.0001
Spray volume	0.0000
Spray volume ²	0.0003
Foliar area	0.0198
Speed advance	0.0001



Foliar \u00e1rea (m²/ha) = Densidad foliar (m²/m³) x Volumen vegetaci\u00f3n (m³/ha)

Validation spray volume recommendation



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Instituto Valenciano de Investigaciones Agrarias (IVIA)

**EPPO Panel on Efficacy Evaluation of Fungicides and Insecticides
Barcelona, 28- 11- 2017**